

Guide to the termites (Isoptera) from the extreme south-west of Western Australia

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Abstract

Keys to genera are provided for soldiers and alates of the species of termite known from the jarrah forest of south-western Australia, and areas west and south of it, with notes on their identification, distribution and biology.

Introduction

Termites comprise a substantial component of the Australian soil fauna, and make a major contribution to the turnover of organic materials in soils (Lee and Wood 1971). They are, in addition, an important part of the diets of many animals and their diversity, distribution and abundance are becoming recognised as useful indicators in the formulation of management strategies in environmental conservation (cf. Braithwaite and Dudzinski 1982; Bunn 1983).

Silvestri (1909) published the first substantial account of Western Australian termites, an account extended by Mjöberg (1920) (Watson and Gay 1983). The most recent detailed statement of our knowledge was that of Hill (1942). However, several substantial papers dealing with particular groups have been published since then (Calaby and Gay 1956, Gay 1968, 1971, Watson and Perry 1981, Gay and Watson 1982) and, although summaries have appeared (Gay 1970, Gay and Calaby 1970, Gay and

Watson 1974), they are of little help in ascertaining which species occur in the south-west, let alone in determining their identities.

During the last few years, Perry and Watson have received increasing numbers of requests for help in identifying termites collected during ecological surveys, many linked to conservation projects affecting the jarrah forest and areas south and west of it, and the need has become apparent for a guide to the termite fauna of that part of south-western Australia.

Use of the keys

Tabular keys to termites from the extreme south-west, here defined as the region of jarrah forest and the areas between it and the coast from Yancheep in the north to east of Albany (Fig. 1), are given in Tables 1-4; the numbers in the keys refer to the relevant figures. The morphological features mentioned in the tables and text are depicted in Fig. 2, on the following illustrations:

antenna	a, g	: marginal tooth	d, i
arolium	h	: tooth	e
eye	g	maxilla	d
femur	h	maxillary palp	g
fontanelle	a, g	nasus	b
frontal tubercle	c	ocellus	g
gula	d	pronotum	f
head width	b, g	tarsal claw	h
mandible	a, g	tarsus	h
		tibia	h
		: apical tooth	i
		: cutting edge	i
		: distal part	e
		: length	e
		: lower condyle	d, e
		: apical spur	h
		wing scale	f
		: length	f

Table 1, to genera (and to species, for those with only one extreme south-western representative), is based on the soldier caste, the diagnostic caste most often encountered, and the character states used can be observed with a 10x hand lens. With the aid of the additional information given in the text and in Figs. 3-6, species of all genera except *Amitermes* and those of the *Termes* complex can readily be identified from the soldiers, but the identification may require a good stereomicroscope fitted with an ocular micrometer. Tables 2 and 3 deal respectively with species of *Amitermes* and the *Termes* complex (Figs. 3b-h, 4a-e). These are difficult termites to identify, and recourse should be made to the text and, in uncertain cases, to the references cited.

A further key to genera (Table 4) is based on winged adults (alates). As with the soldiers of *Amitermes* and the *Termes* complex, the identification of alates is not necessarily easy, and calls for a stereomicroscope and micrometer. To examine the mandibular dentition, it is usually necessary to

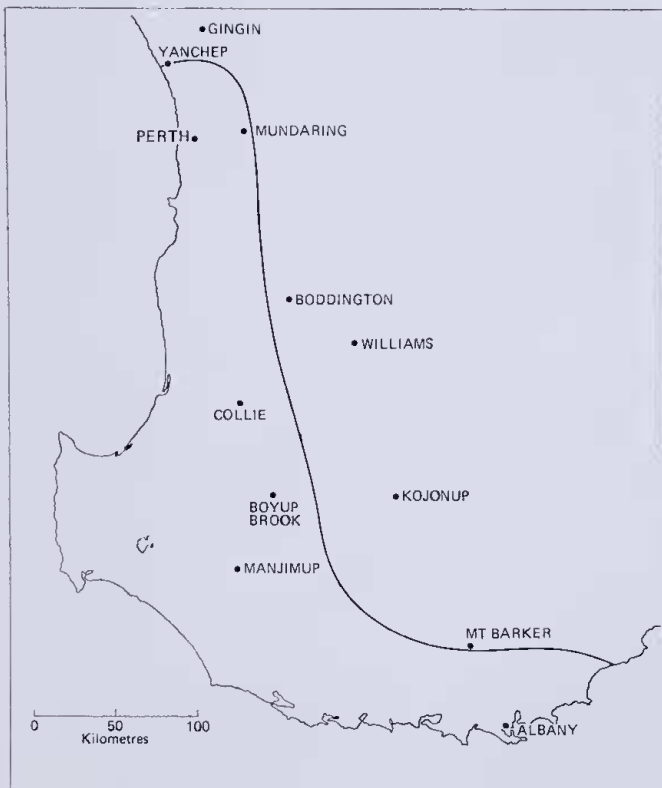


Figure 1.—The extreme south-west of Western Australia.

dissect out the mandibles, which requires fine watchmaker's forceps and mounted needles. The terminology is that of Ahmad (1950) (see also Gay 1970). Further information is given in the text; colour and flight time are often useful characters.

No key is given for workers; although they can usually be identified to genus by their mandibular dentition, which resembles that of the alate (cf. Ahmad 1950, Gay 1970, Campbell and Watson 1975), they can rarely be identified to species.

The tabular keys should be read from left to right. The specimen is allocated to one or other of the character states in the first column, then to a character state in the relevant section of the second column, and so on until it is allocated to a genus or species. Once the genus has been determined, guidance to specific identity can be obtained from the notes on each genus, given in the subsequent section of the paper.

Fauna

The following checklist includes the 32 species of termite of which we have records from the extreme south-west (Fig. 1). The records are those of material held in the Australian National Insect Collection, Canberra, and the D. H. Perry collection, which is to be lodged in the Western Australian Museum; a few are added from the literature. Further details are given in later sections of this paper.

Family Kalotermitidae

- Bifiditermes improbus* (Hagen 1858)
- Cryptotermes austrinus* Gay and Watson 1982
- Kalotermes aemulus* Sewell and Gay 1978
- Kalotermes hilli* Emerson 1949

Family Rhinotermitidae

- Coptotermes acinaciformis raffrayi* Wasmann 1900
- Coptotermes michaelsoni* Silvestri 1909
- Coptotermes* sp. indet.

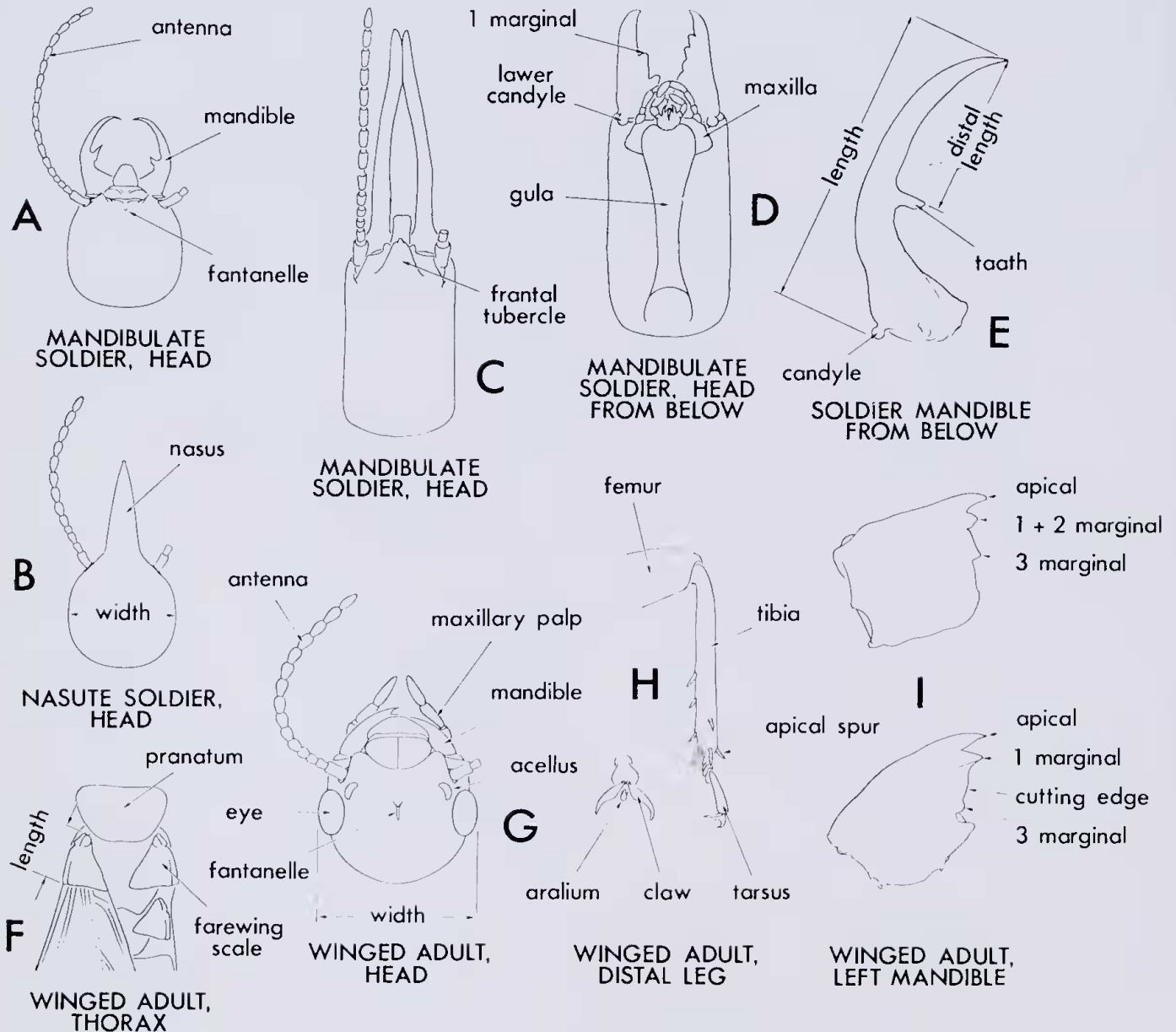


Figure 2.—Morphological features and measurements of termite soldiers and alates (not to scale).

Table 1

Tabular key to termite genera from south-western Australia, based on the soldier caste (for terminology, see figs 2a-e).

Head:	<i>L. mandible:</i> more than one tooth on blade (3, 4a)	<i>Fontanelle:</i> absent (3)	<i>3rd antennal segment:</i> elongate, swollen (3a)	<i>Bifiditermes improbus</i>	
			neither elongate nor swollen (3b)	<i>Head shape:</i> squarish, armoured (3b)	<i>Cryptotermes austrinus</i>
	present (4a)			<i>Kaloterme spp.</i>	
		one tooth on blade (4b-h)			<i>Schedorhinotermes reticulatus</i>
	no prominent teeth on blade, or serrated (5, 6a-d)		<i>Frontal tubercle:</i> present (5a-e)		
		absent (5f-h, 6a-d)	<i>Head shape:</i> oval or tapered (5f-h)	<i>Aperture of fontanelle:</i> concealed from above (5f)	<i>Termes complex</i> (Table 3)
parallel-sided (6a-d)			prominent from above (5g,h)		<i>Ahamitermes hillii</i>
		<i>Mandibles:</i> upcurved in profile (6a, b)		straight in profile (6c, d)	<i>Coptotermes spp.</i>
straight in profile (6c, d)		<i>Heterotermes spp.</i>			
nasute (6e-h)	<i>Head and abdomen:</i> yellowish brown			<i>Microcerotermes spp.</i>	
	pale reddish brown to dark brown	<i>Head, excluding nasus:</i> oval, or tapered to front (6f, g)			<i>Occasitermes occasus</i>
		almost circular from above (6h)			<i>Tumulitermes spp.</i>
				<i>Nasutitermes exitiosus</i>	

Table 2

Tabular key to the extreme south-western Australian species of *Amitermes*, based on the soldier caste (for terminology, see figs 2b, e).

<i>Mandibular tooth:</i> hatchet-shaped (4c)			<i>A. heterognathus</i> (4c)	
barb-shaped (4b, d-h)	<i>Head width:</i> < 0.80 mm	<i>A. insolitus</i> (4d)		
	> 0.90 mm	<i>Mandible length:</i> ≥ 1.00 mm	<i>Amitermes sp.</i> near <i>A. neogermanus</i> (4f)	
		0.80-1.00 mm	<i>Head width:</i> < 1.10 mm	<i>A. pallidiceps</i> (4h)
			≥ 1.10 mm	<i>A. obeuntis</i> (4g)
		< 0.80 mm	<i>Distal part of mandible:</i> 0.34-0.40 mm	<i>A. conformis</i> (4b)
0.30-0.36 mm	<i>A. modicus</i> (4e)			

Table 3

Tabular key to the extreme south-western Australian species in the *Termes* complex, based on the soldier caste (for terminology, see figs 2c, d, h).

<i>Frontal tubercle:</i> reduced (5a)			<i>Hesperotermes infrequens</i> (5a)	
prominent (5b-e)	<i>Mandibles:</i> asymmetrical (5b)	<i>Paracapritermes kraepelinii</i> (5b)		
	symmetrical (5c-e)	<i>Gula:</i> sharply angled posteriorly (5c)	<i>Termes argutus</i> (5c)	
		evenly rounded (5d, e)	<i>Hind tibia:</i> < 1.0 mm long	<i>Termes occidualis</i> (5d)
			> 1.0 mm long	<i>Termes tomentosus</i> (5e)

Table 4

Tabular key to termite genera from south-western Australia, based on the alate caste.

Forewing scale length (2f): > 2x hindwing scale	Arolium (2h): absent					<i>Bifiditermes improbus</i>	
	present	Anterior margin L 3rd marginal tooth (2i): > posterior margin L 1+2nd marginal				<i>Cryptotermes austrinus</i>	
		= posterior margin L 1+2nd marginal				<i>Kalotermes</i> spp.	
< 2x hindwing scale	L mandibular teeth (2i): apical + 3 evident marginal	Head, from above: elongate oval			<i>Heterotermes</i> spp.		
			semicircular behind eyes	Head colour: golden brown	<i>Schedorhinotermes reticulatus</i>		
		reddish brown to very dark brown		<i>Coptotermes</i> spp.			
	apical + 2 evident marginal	Fore tibia (2h): 3 apical spurs	Antennal segments (2g): 13-14			<i>Microcerotermes</i> spp.	
				15	Cutting edge L mandible (2i): notched before 3rd marginal	<i>Termes</i> complex	
		2 apical spurs	Cutting edge L mandible (2i): notched before 3rd marginal		Head width (2g): < 1.15 mm	sinuously curved to 3rd marginal	Apical segment maxillary palp (2g): inflated
				evenly curved to 3rd marginal		not inflated	<i>Anitermes</i> spp.
				> 1.15 mm			<i>Tumulitermes</i> spp.
							<i>Occasitermes occasus</i>
						<i>Nasutitermes exitiosus</i>	

Heterotermes occiduus (Hill 1927)
Heterotermes platycephalus Froggatt 1896
Schedorhinotermes reticulatus (Froggatt 1896)

Family Termitidae

Ahamitermes hillii Nicholls 1929
Anitermes conformis Gay 1968
Anitermes heterognathus Silvestri 1909
Anitermes insolitus Gay 1968
Anitermes modicus Hill 1942
Anitermes obeuntis Silvestri 1909
Anitermes obtusidens Mjöberg 1920
Anitermes pallidiceps Gay 1969
Anitermes sp. near *A. neogermanus* Hill 1942
Hesperotermes infrequens (Hill 1927)
Microcerotermes distinctus Silvestri 1909
Microcerotermes newmani Hill 1927
Microcerotermes serratus (Froggatt 1898)
Nasutitermes coalescens (Mjöberg 1920)
Nasutitermes exitiosus (Hill 1925)
Occasitermes occasus (Silvestri 1909)
Paracapritermes kraepelinii (Silvestri 1909)
Termes argutus (Hill 1929)
Termes occidualis Gay 1971
Termes tomentosus Gay 1971
Tumulitermes apiocephalus (Silvestri 1909)
Tumulitermes westraliensis (Hill 1921)

Genera allied to *Termes* Linnaeus are not necessarily easy to distinguish so, in the keys and the discussions that follow them, *Termes*, *Hesperotermes* Gay and *Paracapritermes* Hill are referred to collectively as the *Termes* complex.

Notes on south-western termite genera and species

The names of genera are listed in the same order as in the checklist, i.e., alphabetically within family.

Family Kalotermitidae

Genus *Bifiditermes* Krishna

Only a single Australian species of *Bifiditermes* is recognised, *B. improbus* (Hill 1942, Krishna 1961, Watson *et al.* 1984) (Fig. 3a). It is morphologically a very variable species that has a wide range in Australia, including Tasmania, but we have only a few records from the extreme south-west.

In common with other kalotermitids, *B. improbus* excavates a series of galleries and chambers in trees, usually eucalypts; there is no connection with the ground. The nest is centred in dead wood, but galleries extend into the live tissue. Some of the chambers contain masses of dry, sand-like faecal pellets, which can be voided through short galleries leading to the outside.

The alates of *B. improbus* are pale brown and very variable in size (Hill 1942). In the extreme south-west, they have been recorded only in January and March, although in south-eastern Australia they can occur between October and April (Hill 1942).

Genus *Cryptotermes* Banks

Gay and Watson (1982) have revised the genus *Cryptotermes* in Australia. Only one species, *C. austrinus*, has so far been found in Western Australia. Although widely distributed and, in places, abundant in central and south-eastern Australia, it

has been recorded from only one locality (Pemberton) within the extreme south-west. It has also been found not far outside the area, between Quindanning and Williams (Gay and Watson 1982). The ridging and rugosity of the soldier head, which acts as a plug to seal galleries under attack from predators, make *C. austrinus* unmistakable [Fig. 3b, and Figs. 7-12 in Gay and Watson (1982)].

As is common in species of *Cryptotermes*, the nests of *C. austrinus* occur in dead stumps, branch stubs and scar tissue, and have no connection with the ground.

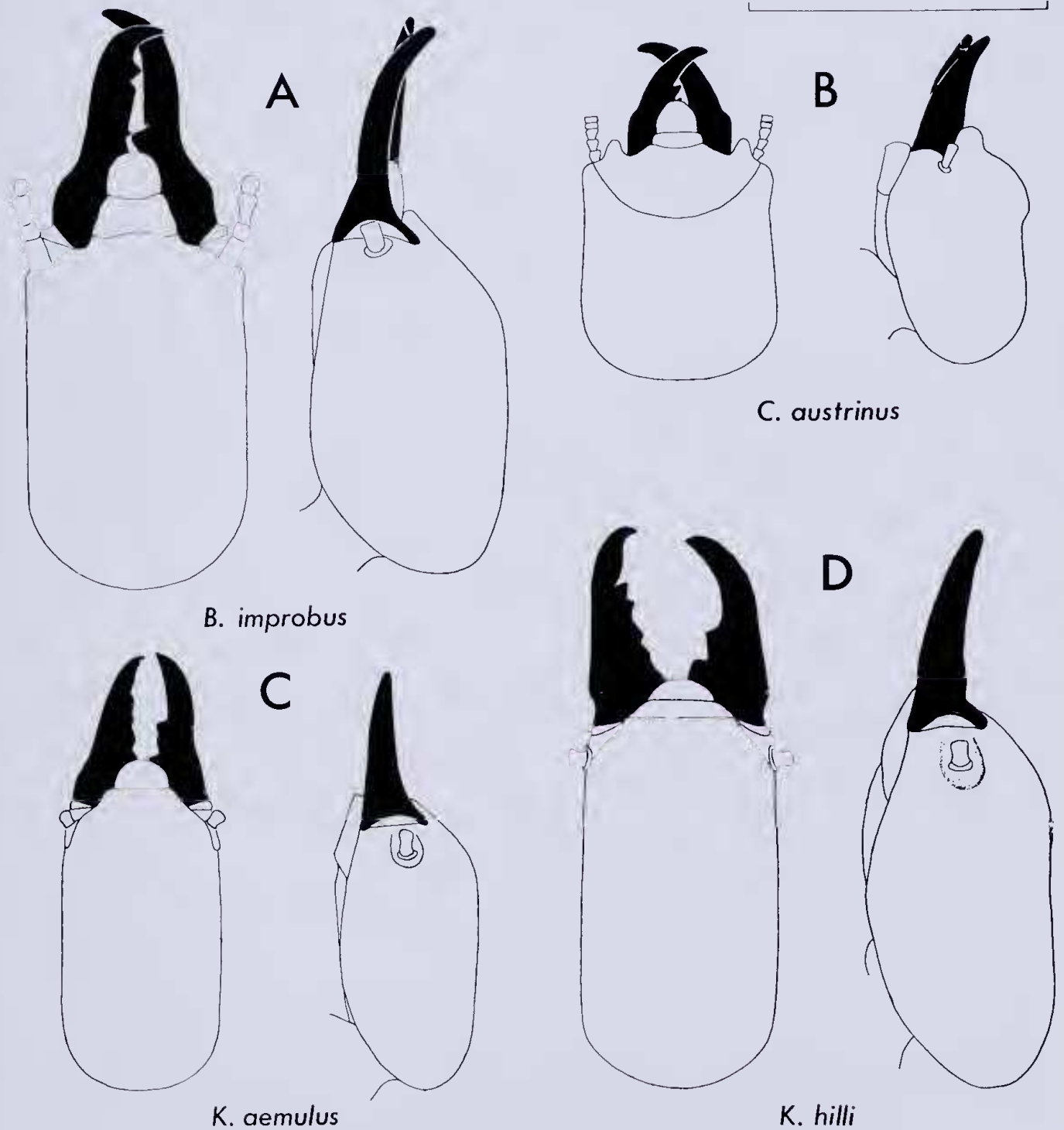


Figure 3.—Dorsal and left lateral views of kalotermitid soldier heads. Scale = 2.0 mm.

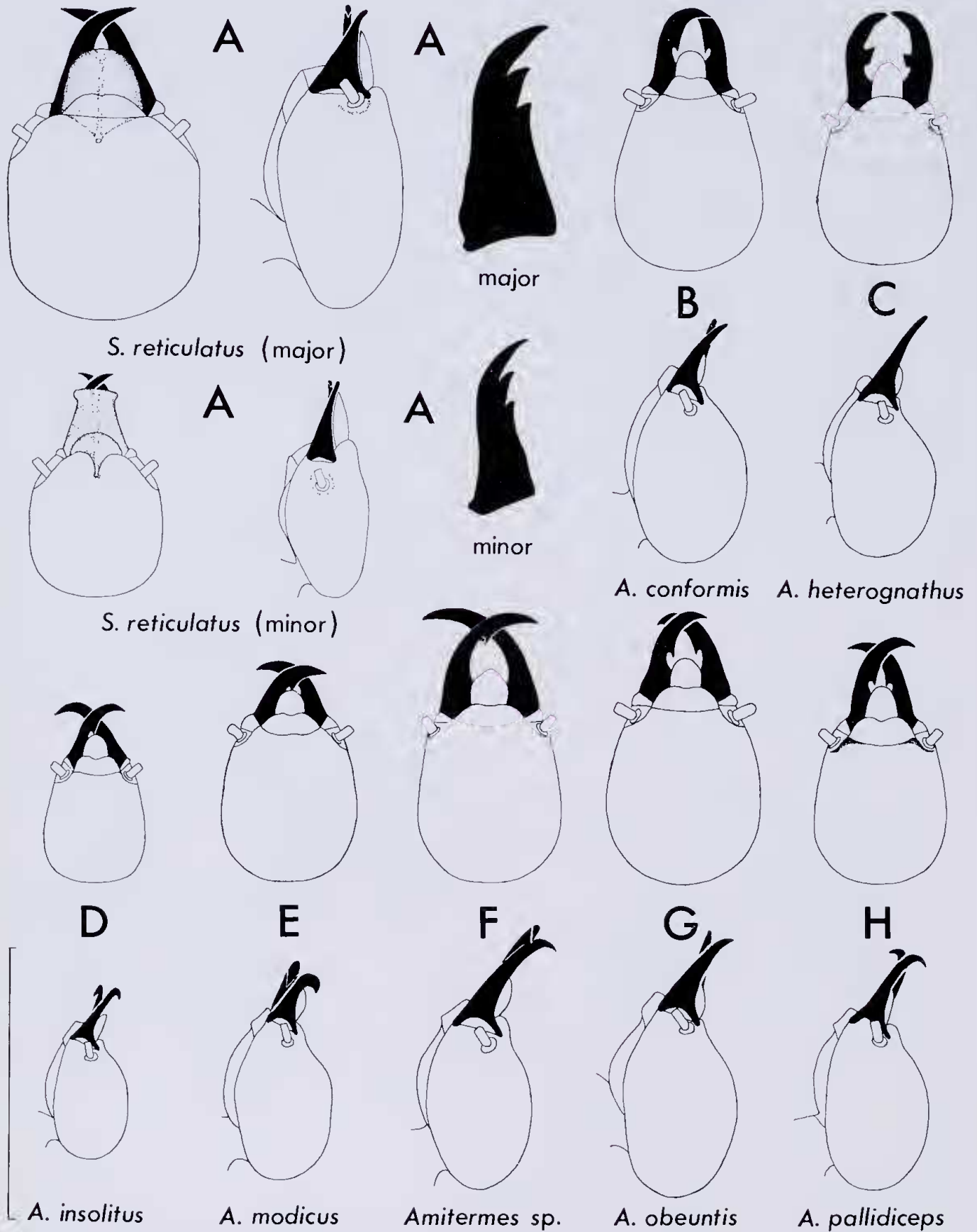


Figure 4.—Dorsal and left lateral views of heads of *Schedorhinotermes* and *Amitermes* soldiers, and left mandibles of *Schedorhinotermes* soldiers. Scale = 2.0 mm (heads) or 1.25 mm (mandibles).

In Western Australia nests have been recorded from several species of eucalypts, and comprise diffuse systems of galleries and chambers which may extend from the dead wood to living sapwood and heartwood (Gay and Watson 1982). The chambers commonly contain large quantities of dry faecal pellets, which are periodically jettisoned through small galleries cut through the outer face of the wood; normally these are plugged when not in use.

Although alates have been collected only in January in Western Australia, they have also been recorded in autumn and spring elsewhere in Australia (Gay and Watson 1982). They are mid-brown to dark chestnut in colour, with faintly brown-tinged wings.

Genus *Kaloterмес* Hagen

Two endemic species of *Kaloterмес* occur in the south-west, *K. aemulus* and *K. hilli*. Sewell and Gay (1978) gave keys for the identification of soldiers and alates. The most useful character for distinguishing soldiers is the ratio between the length of the right mandible (measured from the tip to the end of the lower condyle) and the length of its apical tooth (measured from the tip of the mandible to the tip of the first marginal tooth). This ratio is 2.55-3.13 in *K. aemulus* and 2.10-2.60 in *K. hilli* (Sewell and Gay 1978) (Figs. 3c, d).

The distributions of the two species also differ; *K. aemulus* occurs throughout the extreme south-west, whereas *K. hilli* is southern, extending from Ludlow through Bridgetown to the vicinity of Mt Barker (Sewell and Gay 1978). Both species nest in moist dead wood (on living trees, as well as logs and stumps) in which they cut diffuse systems of galleries and chambers; the nest of *K. aemulus* may extend into the root system. Faecal pellets tend to be damper and to cohere more than those of *Bifiditerмес* or *Cryptoterмес*. Major host plants for both include species of *Banksia* and *Eucalyptus*, and *K. aemulus* has been taken in *Leptospermum* (Sewell and Gay 1978).

Alates of *K. aemulus* have been found in nests from March to May, and of *K. hilli* in January (Sewell and Gay 1978).

Family **Rhinotermitidae**

Genus *Coptoterмес* Wasmann

In economic terms, species of *Coptoterмес* are our most important termites. Three occur in the extreme south-west, the endemic subspecies *raffrayi* of the widespread *C. acinaciformis* (Froggatt), *C. michaelsoni*, and an undescribed species so far known only from alates collected near Jandakot (Calaby and Gay 1956, F. J. Gay unpubl. data). Soldiers of *C.a. raffrayi* and *C. michaelsoni* are readily separable by size; those of *C.a. raffrayi* usually exceed 5 mm in overall length, with heads more than 1.2 mm wide, whereas *C. michaelsoni* soldiers are less than 4.5 mm long and have head widths of 1.0 mm or less (Hill 1942, Calaby and Gay 1956) (Figs. 5g, h). To judge from its alates (see below), the undescribed species from Jandakot is likely to have soldiers similar in size to those of *C. michaelsoni*.

Coptoterмес a. raffrayi occurs throughout the south-west, north at least as far as Northampton, and intergrading with typical *C. acinaciformis* from about Cunderdin and Lake King in the west eastwards to the vicinity of Kalgoorlie and Norseman (Calaby and Gay 1956). *C. michaelsoni*, on the other hand, has a restricted range, extending perhaps 100 km south and east from Perth, and 75 km north (Calaby and Gay 1956). The two coexist on the Swan Coastal Plain, where both can be abundant. Both species damage sound timber in service, *C.a. raffrayi* severely so.

Coptoterмес a. raffrayi builds large nests of clay and carton (*i.e.*, faecal material) in or under living or dead eucalypt trunks or stumps, and occasionally takes over mounds of *Nasutiterмес exitiosus* (Calaby and Gay 1956, J. A. L. Watson unpubl. data). It often feeds on fungus-affected heartwood of living trees (Perry *et al.* 1985), filling the resulting hollows with brown "mud gut", composed largely of faecal material, and sealing cracks in the trunk with clay. The nests of *C. michaelsoni* are unknown, but are not associated with trees (Calaby and Gay 1956); unlike *C.a. raffrayi*, *C. michaelsoni* can occur away from eucalypts. At feeding sites in dead wood, both species build a network of patchy brown carton (*cf.* Watson and Barrett 1981).

The alates of *C. michaelsoni*, and of the undescribed species, are relatively small, with heads between 1.0 and 1.2 mm wide. *C. michaelsoni* has a dark brown head, but the head of the undescribed species is pale reddish brown. *C.a. raffrayi* alates have dark chestnut-brown heads and are larger, with head widths greater than 1.2 mm, sometimes up to 1.4 mm. *C. michaelsoni* flies from August to November, and the undescribed species was recorded in August; *C.a. raffrayi* flies later, from October to early January, the main flights being in the first half of November (Hill 1942, Calaby and Gay 1956, F. J. Gay unpubl. data).

Genus *Heteroterмес* Froggatt

The two south-western species of *Heteroterмес*, *H. occiduus* and *H. platycephalus*, differ in size; the soldiers of *H. occiduus* are less than 5 mm long, with a head width of up to 0.9 mm, whereas those of *H. platycephalus* exceed 5 mm in length, and their heads are more than 1.1 mm wide (Hill 1942) (Figs. 6a, b). Both species are primarily Western Australian, although both have been recorded in South or central Australia. *H. occiduus* is closely related to the widely distributed south-eastern species *H. ferox* (Froggatt) (*cf.* Hill 1942, F. J. Gay unpubl. data), and ranges north to the north-west coast and Barrow Island, east through the Western Australian border and south to the Manjimup area, Denmark and Esperance. *H. platycephalus* is more southern, being known from Northampton and Mileura Station, in the Upper Murchison, to the south coast from Augusta to the Madura Pass.

The two species have similar habits. The nest is subterranean, apparently consisting of a rambling system of chambers and galleries, sometimes built in the nests of other species of termite. The workers feed on the sapwood or fungus-affected heartwood of a wide range of species, usually on or in the soil. Established galleries are lined with a mottled layer of faecal material, pale brown to grey, sometimes almost white.

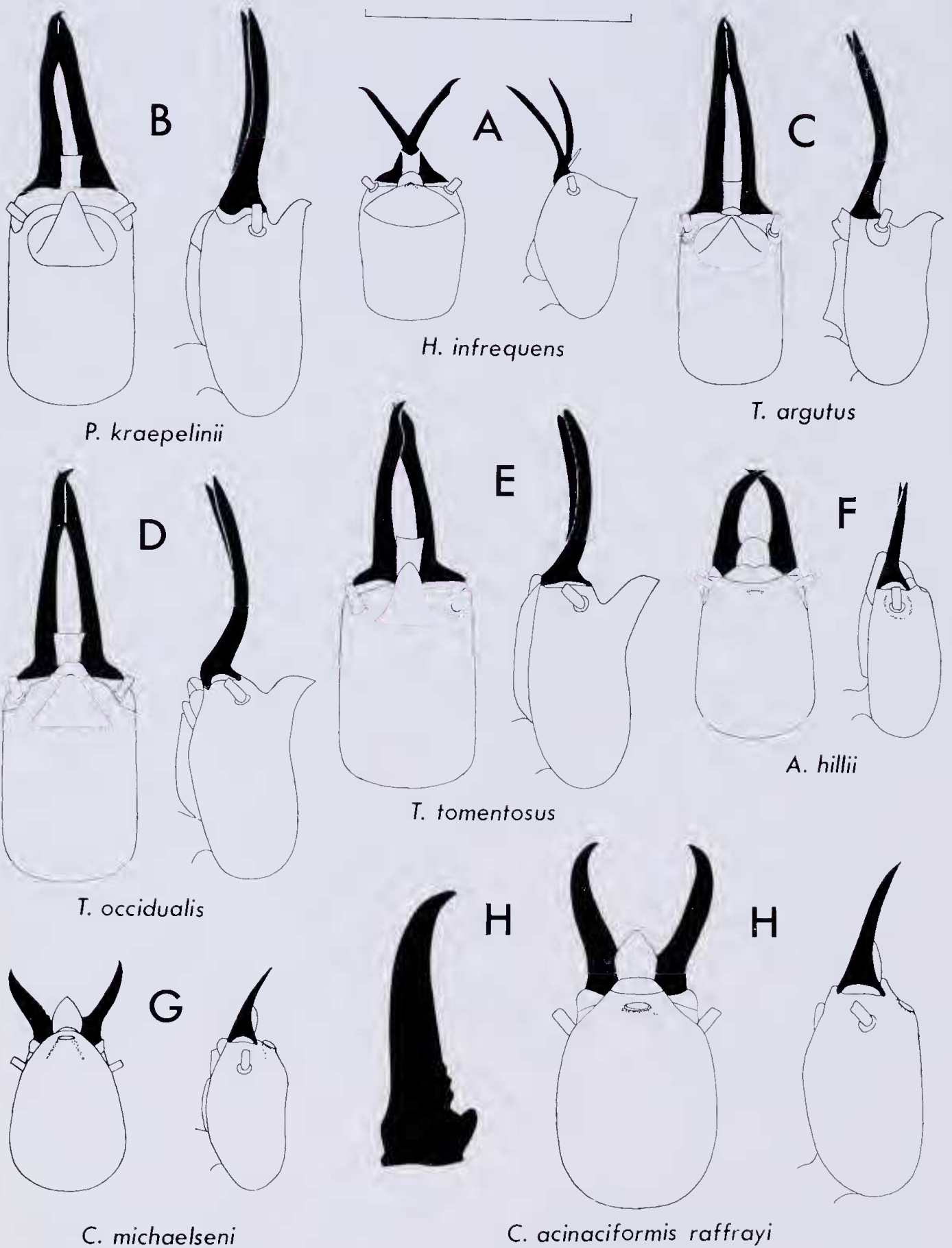


Figure 5.—Dorsal and left lateral views of soldier heads of the *Termes* complex, *Ahamitermes* and *Coptotermes*, and left mandible of *Coptotermes* soldier. Scale = 2.0 mm (heads) or 1.25 mm (mandible).

Alates of *H. occiduus* are dark brown with brown-tinted wings, whereas winged *H. platycephalus* are pale brown with wings of similar hue. Both species produce their alates in summer to autumn, *H. occiduus* in February to June and *H. platycephalus* from January to April.

Genus *Schedorhinotermes* Silvestri

Schedorhinotermes reticulatus is the only south-western species of termite that regularly has markedly dimorphic soldiers, large major soldiers and small minors (Fig. 4a). Although widely distributed in southern Australia (cf. Hill 1942), *S. reticulatus* does not extend far into the extreme south-west, being known only from Wanneroo northwards.

The nest of *S. reticulatus* has not been described, but it probably resembles the nests of other species of *Schedorhinotermes*, i.e., a small aggregation of chambers, with or without a defined nursery region, in the base of a stump or post, in logs or derelict termite mounds or, perhaps, in the soil (Hill 1942, Miller 1981). Like species of *Coptotermes*, *S. reticulatus* can damage sound timber, but it also feeds on weathered or rotted wood, and materials such as particle board (Hill 1942, Ratcliffe *et al.* 1952, J. A. L. Watson unpubl. data), lining its galleries with mottled brown faecal deposits. It sometimes ensheaths exposed surfaces with fragile earthen walling (Gay and Calaby 1970).

The alates are golden brown (Hill 1942), but their flight time in the extreme south-west has not been recorded. Elsewhere in Western Australia alates have been collected in April and May, and in south-eastern Australia, as early as January.

Family Termitidae

Genus *Ahamitermes* Mjöberg

Ahamitermes contains only one south-western species, *A. hillii* (Fig. 5f), which is known from as far east as Zanthus and Mt. Ragged and north to the lower Murchison. A related species, *Ahamitermes inchus* Gay, has been recorded north and east of Geraldton and Northampton (Gay 1955).

Species of *Ahamitermes* are inquiline in the fabric of live *Coptotermes* nests, in trees and in mounds. The gallery systems of the inquiline and its host are separate. *A. hillii* lives in the nests of *C. acinaciformis*, of both subspecies, forming its nest just above the nursery of its host (Gay 1955). As far as known, *A. hillii* subsists on carton, i.e., those parts of the host's nest built predominantly of faecal material.

Alates of *A. hillii* are released in February to April, from small domes, 5-10 cm high on the foot of the host mound, or near the base of the tree in which the host is living. They are predominantly dark brown above, with paler brown wings (Hill 1942).

Genus *Amitermes* Silvestri

Amitermes is the largest of the termite genera recorded from Australia, with upwards of 100 Australian species known (Gay 1968, F. J. Gay and J. A. L. Watson unpubl. data). Eight species have been recorded from the extreme south-west, but the status of one of these, *Amitermes obtusidens*, is uncertain (see below). A key to soldiers of the

remaining seven is given in Table 3, and Gay (1968) has provided a key to the alates of the then-known Australian species.

Amitermes conformis (Fig. 4b).—*A. conformis* is known only from the south-west, east to Hyden and Kirwan and north to Yuna; it extends to the south coast. It is closely related to *A. modicus*. Its workings are typical of *Amitermes*, the galleries and chambers having dark brownish, woody walls. It may occur in mounds of other species of termite and, near Denmark, has been collected from mounds, apparently self-built, approximately 20 cm in diameter and 5-10 cm high. It feeds on sapwood and decay-affected heartwood of a range of tree species.

Alates have been taken on the wing in February to May (Gay 1968).

Amitermes heterognathus (Fig. 4c).—*A. heterognathus* is also endemic to south-western Australia. It has been recorded as far north as Northampton, and east to Corrigin and Gnowangerup. In the extreme south-west, *A. heterognathus* extends to the south coast. Its galleries and chambers have grey-brown, woody linings, and it may ensheath its food (fungus-affected wood, cow dung and other plant debris) with fragile earthen walling. It also invades the fabric of termite mounds.

Alates have been collected from mid-February until early April (Gay 1968).

Amitermes insolitus (Fig. 4d).—There is very little information on *A. insolitus*. Although the first series known was collected from the gut of a frog, *Myobatrachus gouldi* (Gray) (Gay 1968), labelled as having been collected in Perth, subsequent searches on the Swan Coastal Plain have failed to uncover further material. *A. insolitus* is, however, present at eneabba, where it constructs fragile chambers and galleries in the soil. It apparently feeds on vegetable debris.

Alates have been collected in April (Gay 1968).

Amitermes modicus (Fig. 4e).—*A. modicus* is closely similar to *A. conformis* but has a wide distribution in southern Australia, occurring in all the southern mainland states. In Western Australia it has been recorded north to Three Springs, east to the South Australian border, and south to the coast at Israelite Bay. In the extreme south-west, it is known as far south as the Manjimup area and Denmark. It is common on the Swan Coastal Plain.

The biology of *A. modicus* in the south-west is much like that of *A. heterognathus*. *A. modicus* feeds primarily on weathered or rotted wood, but has also been collected from dry cow dung and plant debris (Ferrar and Watson 1970). It also invades the mounds of other termites.

South-western records of alates have been made in February to April (Gay 1968).

Amitermes obeuntis (Fig. 4g).—Widespread in the southern part of Western Australia, *A. obeuntis* is also known from a few localities in South Australia (F. J. Gay unpubl. data). In the west it has been taken as far north as Yuna, east to Karonie and Balladonia and, in the extreme south-west, along the entire south coast where soils are suitable. It is extremely abundant in many areas.

Amitermes obeuntis is usually a mound-builder. The mounds are of clay, which restricts the species to soils where clay is accessible, and are commonly 5-10 cm high and 30 cm or more wide, although some mounds are 60-90 cm high. They are often irregular in shape, unlike the mounds of *Nasutitermes exitiosus* (see below), and their central region is made up of broad, transversely oriented chambers. The mounds provide housing for many other species of termite, and is not uncommon to find several species of invaders in a single mound. Conversely, *A. obeuntis* may be found in nests of other termites, and in chambers in the soil. Its diet apparently consists of weathered wood, but there are a few records of finely comminuted forage stored in its mounds.

Alates can be found in the nests from late February until June (Hill 1942, D. H. Perry unpubl. data).

Amitermes obtusideus.—Hill (1942) recorded *A. obtusideus* from the extreme south-west. A well-known eastern, northern and central Australian species, it has not been found in Western Australia again, and its status as a south-western termite must be regarded as very doubtful. It has, therefore, been omitted from the key. The soldier has blunt, peg-like mandibular teeth, unlike those of any other extreme south-western termite (cf. Hill 1942).

Amitermes pallidiceps (Fig. 4h).—Originally described as *A. pallidus*, *A. pallidiceps* is poorly known (Gay 1968, 1969). It has been collected only from Upper Swan and near Bindoon, from galleries in the soil and what might have been a nest in an old mound of *Nasutitermes exitiosus*. Its diet is unknown.

Alates have been recorded in April (Gay 1968).

Amitermes sp. near *A. neogermanus* (Fig. 4f).—As with some other south-western *Amitermes*, this undescribed species is little known. It has been recorded only from siliceous sands between Eneabba and Gnangara, but it could well extend farther south. All the known specimens were collected from brown, woody-walled chambers and galleries in the soil. Presumably, this *Amitermes* does not feed on wood but, perhaps, on other buried plant material. The alate is unknown.

Genus *Hesperotermes* Gay

See below, under *Termites* complex.

Genus *Microcerotermes* Silvestri

The Australian species of *Microcerotermes* are much in need of revision. The status of the south-western species is poorly understood. Three have been recorded, *M. distinctus*, *M. newmani* and *M. serratus*, but south-western material attributed to *M. distinctus* and *M. serratus* is very limited. Furthermore, *M. serratus* is a very variable species (Hill 1942), and may constitute a species-complex; its occurrence in the extreme south-west is open to doubt (D. H. Perry unpubl. data). We therefore confine our comments to *M. distinctus* and *M. newmani*.

Microcerotermes distinctus and *M. newmani* can readily be identified by differences in size; *M. distinctus* soldiers have a body length usually exceeding

6 mm and a head width of 0.87-0.98 mm, whereas *M. newmani* is smaller, the soldier being 4.2 to 5.3 mm long with a head 0.74-0.82 mm wide (Hill 1942) (Figs. 6c, d). *M. distinctus* is widely distributed in inland Australia, including the Western Australian wheat belt, but has been recorded from the extreme south-west only in and north of the Perth metropolitan area, including Mundaring, and south on the Darling Scarp at Wagerup. *M. newmani*, in contrast, is confined to Western and South Australia and, in W.A., extends north at least to Barrow Island and Jigalong Mission, east to Warburton Mission, and south to the coast.

Little is known of the nests of *Microcerotermes* in the south-west (cf. Hill 1942). Both south-western species inhabit galleries and chambers in the soil, in wood, and in the nests of other species of termite. Reproductives and young have been found in brown woody cells in clumps some 10 cm in diameter, and in old mounds. Both species commonly feed on fungus-affected wood, usually on or near the ground, plant debris and dung (cf. Ferrar and Watson 1970), although *M. serratus* has recently caused extensive damage to railway sleepers in the Pilbara region (J. E. Barnacle pers. comm.). The galleries of *Microcerotermes* are built of pale to, more commonly, dark brown carton.

Alates of *M. distinctus* are predominantly dark brown, with smoky brown wings, whereas *M. newmani* has reddish brown alates (Hill 1942). In the extreme south-west, *M. distinctus* alates have been collected in February and March, and those of *M. newmani* in December to February. Farther inland, alates of *M. distinctus* have been recorded from August to May, but only in January and February in the case of *M. newmani*.

Genus *Nasutitermes* Dudley

Although two species of *Nasutitermes* have been recorded from the extreme south-west, it seems likely that only one occurs there. *Nasutitermes coalescens*, originally described from Mundaring (Mjöberg 1920), has not been recorded from the south-west since (Hill 1942), and our more recent data indicate that it is a north-western species. We have, therefore, disregarded it in constructing the key. *Nasutitermes exitiosus*, on the other hand, occurs virtually throughout southern mainland Australia, and is of some economic importance (Hill 1942; Watson and Barrett 1981) (Fig. 6h). The subject of many studies, it is better known than any other Australian species of termite (Watson and Gay 1981).

Throughout the extreme south-west, but not necessarily in the inland, *N. exitiosus* builds uniformly domed mounds, commonly up to 1 m in diameter and approximately half that in height. The outer casing of the mound is usually friable, but the inner material is tough and woody carton, enclosing a central nursery with thin, fragile walls (cf. Hill 1942; Watson and Barrett 1981). Subterranean galleries radiate out to about 50 m from the mound, to feeding sites in dead standing or fallen timber, or in litter; both sound and fungus-affected wood are eaten.

There are a few records of *N. exitiosus* hollowing-out living trees (J. A. L. Watson and H. M. Abbey unpubl. data), and many of it attacking timber in service, including buildings (Watson and Barrett 1981). Gallery work, and the material used to fill hollowed timber, are dark brown.

Alates of *N. exitiosus* have reddish brown to dark brown bodies and yellowish brown, translucent wings (Hill 1942). The main flight is in spring, commonly October, but a second flight of alates may be produced, coinciding with late summer or autumn rains (Watson and Abbey 1985).

Genus *Occasitermes* Holmgren

Two species of *Occasitermes* are known, one, *O. occasus*, being widely distributed in south-western Australia, with an outlier on the Eyre Peninsula in South Australia (Calaby 1956, Gay 1974). *O. occasus* is abundant in the extreme south-west, where it is the only nasute termite with yellowish-headed soldiers (Fig. 6e).

The nest of *O. occasus* apparently consists of widely-spaced galleries and chambers in the soil; no compact nest has been discovered. It also commonly occurs in mounds of *Amitermes obeuntis*. *O. occasus* feeds on sapwood and weathered, fungus-affected heartwood from a range of trees (Gay 1974), and its galleries have pale brown walls.

The alates are pale reddish to tawny brown, and have been collected throughout the year (Hill 1942, Gay and Calaby 1970, Gay 1974).

Genus *Paracapritermes* Hill

See below, under *Termes* complex.

Generic complex *Termes* Linnaeus

Genera of the *Termes* complex all have soldiers with long mandibles, often comparable in length with the head capsule (Figs. 5a-e); the soldier can forcibly click them into a crossed position. The taxonomy of the Australian members of the complex is at present under study (L. R. Miller unpubl. data), and the southern Australian members, including those from the south-west, were reviewed by Gay (1971). The five south-western species are allocated to three genera but, as is common in the complex, neither genera nor species are necessarily easy to identify. It is, therefore, best to treat them together.

Soldiers of the five species are keyed in Table 3.

Hesperotermes infrequens, the only species of its genus, is entirely south-western, extending north to Eneabba, east to Woorooloo and to near Williams, and south to the coast. The soldier is distinguished not only by its reduced frontal tubercle (Fig. 5a), but also by its reddish brown head capsule.

The only south-western species of *Paracapritermes*, *P. kraepeliiiii*, has asymmetrically swollen mandibles in the soldier, the left mandible being markedly more irregular in width than the right (cf. Gay 1971) (Fig. 5b). However, when the mandibles are crossed,

their asymmetry may be difficult to recognise unless they are dissected out and placed in an uncrossed alignment. *P. kraepeliiiii* is endemic to Western Australia but is more widespread than *H. infrequens*, with many records from the wheat belt and a few as far east as Leonora, but none in the extreme south.

Of the three species of *Termes* one, *T. argutus*, occurs widely in southern and central Australia. The southernmost record in the extreme south-west is from Hamel, but *T. argutus* is, apparently, common in the Kojonup-Tambellup-Gnowangerup area, and north and east of it. The other two species, *T. occidualis* and *T. tomentosus*, are both endemic and have ranges closely overlapping that of *H. infrequens*.

All south-western members of the complex inhabit galleries and chambers in the soil or in the nests of other species of termite. However, in the southern part of the extreme south-west, *T. occidualis* builds low, blackish, woody carton and soil mounds. All species feed on rotted wood and plant debris, and their galleries are dark-walled.

Gay (1971) included a key to the alates. They have been recorded during the following months: *H. infrequens*, March-April; *P. kraepeliiiii*, February-March; *T. argutus*, February (in W.A.); *T. occidualis*, January-April; and *T. tomentosus*, April.

Genus *Tumulitermes* Holmgren

Of the two south-western species of *Tumulitermes* one, *T. apiocephalus*, has also been recorded from the western slopes of New South Wales, whereas *T. westraliensis* is endemic. Both occur throughout much, if not all, of the extreme south-west. *T. apiocephalus* ranges north at least as far as Shark Bay and east, within the State, to Paynes Find and Salmon Gums, but *T. westraliensis* has a slightly more southern range, north to Three Springs and east to Esperance. There is also a single series from Giles.

Tumulitermes apiocephalus is a small species, the soldier being less than 4 mm long, with a pale, reddish brown head, whereas the soldier of *T. westraliensis* is larger, usually much longer than 4 mm, with a very dark brown, almost black, head (Figs. 6f, g). There is occasional soldier dimorphism in both species.

Tumulitermes apiocephalus lives in galleries and chambers, lined with dark brown carton, in the soil and in mounds of other species of termite. It feeds on plant debris and rotted wood, and may store finely comminuted forage. *T. westraliensis*, however, builds low, irregular, clay mounds and, hence, is not found on deep sand. It eats grasses, forbs and dry plant litter, which it gathers in the open at night and stores in its mounds. It is the only harvester termite in the extreme south-west, for the most highly specialised of the Australian harvester termites, of the genus *Drepanotermes* Silvestri, narrowly fail to extend into the region (cf. Watson and Perry 1981).

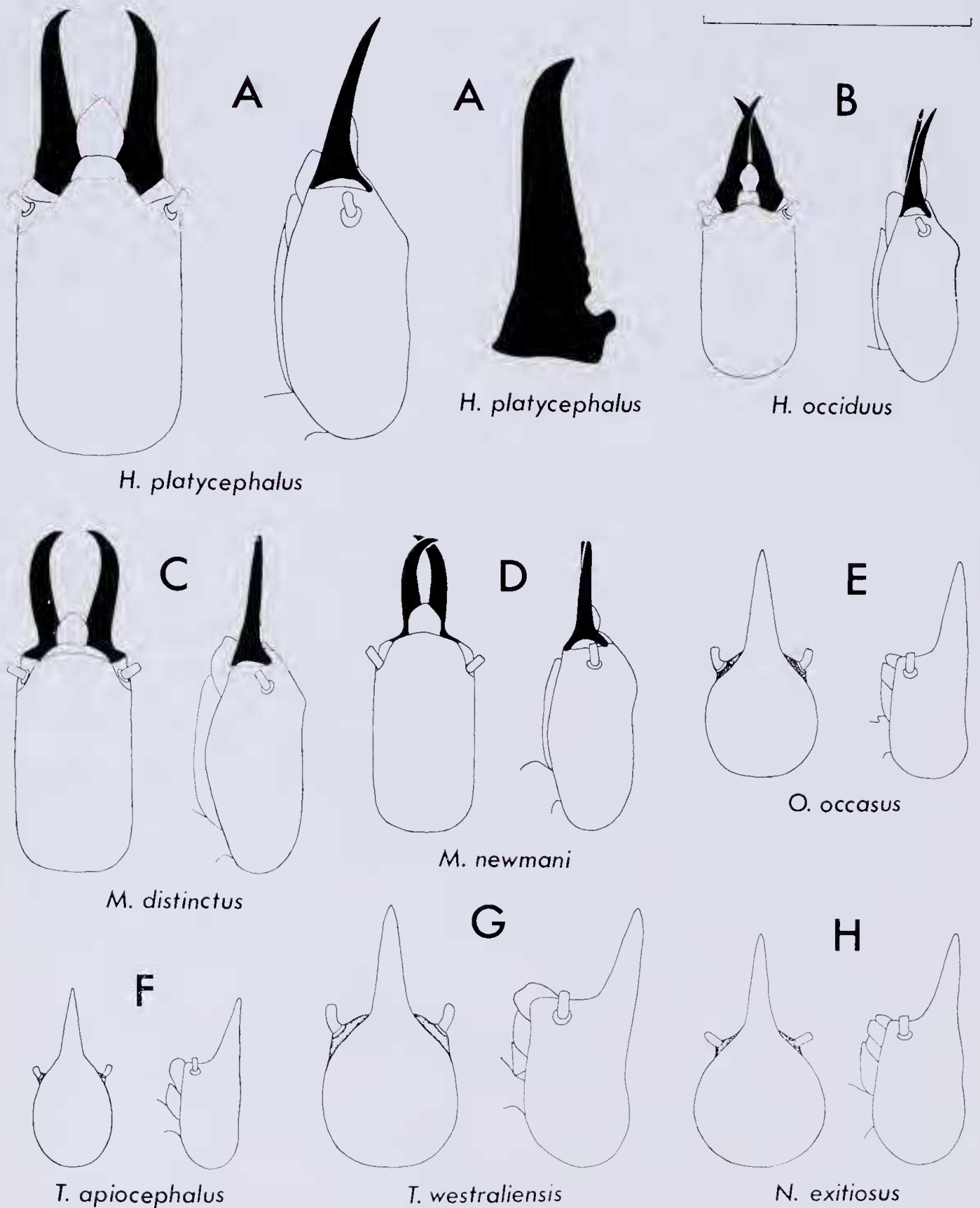


Figure 6.—Dorsal and left lateral views of soldier heads of *Heterotermes*, *Microcerotermes* and nasute genera, and left mandible of *Heterotermes* Soldiers. Scale = 2.0 mm (heads) or 1.25 mm (mandible).

The alates of both species are very dark brown, almost black, with brown wings (Hill 1942). Alates of *T. apiocephalus* have been collected in the south-west from October to February, and of *T. westraliensis* in September to July, perhaps occurring throughout the year (cf. Gay and Calaby 1970).

A third species, *T. comatus* (Hill), has been recorded slightly north of Yanchep. It is widespread elsewhere in Australia, including the Western Australian wheat belt, and may occur within the extreme south-west. The soldier has an orange-brown head, paler than that of *T. apiocephalus*, and colonies near Yanchep are housed in small, dark brown woody nests, approximately 30 cm in diameter, the tops of which just subtend the soil surface. *T. comatus* feeds under earthen sheathing, on weathered wood and plant debris.

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